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INFLUENCE OF DIFFERENT LEVELS OF RUMEN CONTENT AS A REPLACEMENT FOR GRASS MEAL IN COMPOUND FEED ON THE PRODUCTIVITY OF KAZAKH FINE-WOOL SHEEP

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ABSTRACT: This study evaluated the effects of replacing grass meal with different inclusion levels of dried rumen content on the growth performance of Kazakh fine-wool sheep. Twenty five-month-old intact male sheep (initial body weight 32.1 ± 0.20 kg) were randomly allocated to four dietary treatment groups for 60 days following a fifteen-day adaptation period. The control diet contained no rumen content, while experimental diets included 10%, 20%, and 30% dried rumen content (a mixture of cattle and sheep rumen content at a ratio of 60:40). Inclusion of rumen content at 10–20% significantly improved average daily gain and feed conversion ratio compared to the control diet ($P < 0.05$), whereas a 30% inclusion level reduced feed palatability and productive performance. No adverse effects on animal health were observed during the experiment. The results indicate that dried rumen content can be safely used as a partial replacement for grass meal in sheep diets at inclusion levels up to 20%.

Keywords: Alternative feedstuffs; Feed palatability; Sheep; Rumen content; Ruminant nutrition

INTRODUCTION

Global demand for meat and livestock products has increased in recent decades, driving a rapid expansion of animal production. Global meat output now exceeds 340 million tonnes per year, and abattoirs generate vast quantities of byproducts. Roughly half of a slaughtered animal's weight remains as offal and inedible by-products (blood, organs, rumen contents, etc.). Efficient valorization of these by-products is critical: by-product reuse can alleviate feed shortages, decrease production costs, and reduce environmental pollution (Alibekov et al., 2024). Rumen content is readily available in slaughterhouses and is rich in nutrients: it typically contains crude protein along with microbial biomass, volatile fatty acids, minerals and B vitamins (Alao et al., 2017; Cherdthong, 2020, Soressa et al., 2025).

Experimental evidence supports the potential of rumen content as a feed ingredient (Cherdthong, 2020; Lazarus et al., 2025). In various trials, animals fed diets containing moderate levels of dried rumen content indicated no reduction in productive performance. Previous studies indicated that dried rumen content can be incorporated into poultry diets without adverse effects on growth performance or feed efficiency (Okorie, 2006; Yitbarek et al., 2020, Mishra et al., 2015, Adeniji et al., 2021). According to T. F. Mbahi, cane can be included in the diet of weaned rabbits in quantities of up to 40% without negative effects on growth rates, blood composition, carcass characteristics and internal organs (Mbahi et al., 2020).

Despite these promising results, research on the use of rumen contents in sheep diets remains limited, particularly regarding the conditions of Central Asia. Only a small number of studies have investigated the application of the slaughter by-product in ruminant feeding; therefore, data regarding the use of such by-products in Kazakh fine-wool sheep are virtually rare. This gap is especially relevant to the scale and ongoing growth of sheep production in Kazakhstan. Currently, the country produces approximately 1.0 million tons of meat annually (Bureau of National Statistics of Kazakhstan, 2025) while a considerable proportion of slaughter by-products, including rumen contents, remains underutilized (Alibekov et al., 2024). With the continuing increase in livestock numbers and the corresponding rise in slaughter waste volumes, the evaluation of feed applications for such by-products demands a timely and practically important research direction.

The aim of the present study was to evaluate the effects of using different levels of cattle rumen contents in compound feeds on the productive performance of Kazakh fine-wool sheep. Determining optimal inclusion levels and their effects on growth and production parameters may contribute to the existing literature and provide practical recommendations to reduce feed costs and promote the rational utilization of waste products in the meat-processing industry.

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MATERIALS AND METHODS

Ethical approval

All animal procedures were conducted in accordance with the Law of the Republic of Kazakhstan "On Responsible Treatment of Animals" (2021) and international guidelines for the welfare of farm animals. The experimental protocol was approved by the Ethics Committee of the Kazakh Research Institute of Processing and Food Industry LLP.

Preparation of ingredients

Rumen contents from clinically healthy cattle and sheep were collected at the slaughterhouse of LLP "Rural Industrial Complex DALA FOOD" following veterinary inspection. In total, approximately 100 kg of cattle rumen content and 50 kg of sheep rumen content were collected, pooled, and transported to the feed mill of the Kazakh Research Institute of Processing and Food Industry LLP. Animals were raised under typical local production systems: the cattle received a roughage-based fattening diet with concentrates, while the sheep were fed pasture grass and hay. The rumen contents were dried at 48°C to a moisture content of 9.8% and ground into grits. Other feed ingredients (triticale, wheat bran, brewer's grain, grass meal, and fillers) were purchased locally (Almaty, Kazakhstan) and subjected to standard quality control procedures. Table 1 shows the chemical composition of the main components of the diet (triticale, wheat bran, brewer's grain, and grass meal (alfalfa).

Table 1 - Chemical composition of the main components of the diet,%

Variable	Triticale	Wheat bran	Brewer's grain	Grass meal
Dry matter (DM, %)	89.89	88.90	91.33	88.86
Crude protein (CP, %)	16.81	14.88	23.44	14.13
Fat (%)	1.32	3.16	7.75	3.85
Crude fiber (CF, %)	2.99	8.76	14.3	29.09
Nitrogen-free extract (NFE, %)	66.79	57.57	43.44	33.67
Sugar (%)	1.63	2.06	-	-
Starch (%)	51.51	12.69	-	-
Ash (%)	1.97	4.53	2.5	8.11
Calcium (Ca, %)	0.09	0.22	0.37	1.59
Phosphorus (P, %)	0.30	0.71	0.5	0.18

Feed formulation and production

Four groups of compound feeds were formulated: a control diet group without rumen content (A) and three experimental diet groups containing 10% (B), 20% (C), and 30% (D) rumen content. The three levels experimental diet were selected to represent low, moderate, and high replacement rates to determine the optimal diet level for Kazakh fine-wool sheep. Grass meal accounted for 30% in the control diet was progressively replaced by rumen content in the experimental diets; in the 30% rumen diet, grass meal was completely excluded. A mixture of cattle and sheep rumen contents (60:40) was used in all experimental feeds. Table 2 shows the formula for combined feed for sheep with the addition of rumen content. Feed production contained mixing rumen content with fillers and zeolite (adsorbent), moistening to ~20% moisture, granulation, and subsequent cooling and drying.

Animals and experimental design

Twenty healthy Kazakh fine-wool sheep (intact males), five-months old, with an initial body weight of 32.10 ± 0.09 kg, were randomly allocated to four groups (n = 5) using a completely randomized design balanced by body weight. Animals were housed individually under identical zoo-hygienic conditions with free access to water.

Feeding regimen and data collection

Sheep were fed once daily at 08:00 h for 75 days: a fifteen-day adaptation period and a sixty-day experimental period. Experimental diets were introduced gradually during adaptation. Daily feed intake was recorded by weighing feed offered and refusals. Feed palatability was expressed as the percentage of feed was consumed. Animals were weighed weekly before feeding to determine total and average daily weight gain. Feed conversion ratio (FCR) was calculated as total dry matter intake divided by live weight gain. Animal health was monitored daily during the experiment. Feed palatability (acceptability) was measured as the percentage of feed consumed based on the amount offered, following the formula: Palatability (%) = (Feed intake / Feed offered) × 100. Animal health was monitored daily during the experiment. Health status was evaluated daily by visual observation and clinical examination. The health indicators monitored during the experiment were appetite, general behavior, locomotor activity, and fecal consistency. Fecal consistency was scored using a five-point scale as: 1 = watery diarrhea, 2 = loose feces, 3 = normal well-formed feces, 4 = firm feces, and 5 = very dry feces. During the experimental period, none of the animals showed clinical signs of digestive disturbances (diarrhea, bloating, lethargy, or reduced feed intake), and no clinically relevant abnormalities were detected.

Table 2 - Formula for combined feed for sheep with the addition of rumen content, %

Variable	A	B	C	D
Rumen content mix (60% cattle + 40% sheep)	0	10	20	30
Triticale	27	27	27	27
Wheat bran	19	19	19	19
Brewer's grains	19	19	19	19
Grass meal	30	20	10	-
Premix*	1	1	1	1
Salt	1	1	1	1
Zeolite	3	3	3	3
Dry matter (DM, %)	91.60	91.00	91.10	94.20
Crude protein (CP, %)	14.07	14.38	14.74	14.54
Fat (%)	2.33	2.42	2.64	1.82
Crude fiber (CF, %)	12.19	12.67	13.55	14.75
Nitrogen-free extract (NFE, %)	55.85	53.76	51.48	55.66
Sugar (%)	1.17	1.23	1.32	1.92
Starch (%)	20.63	19.71	20.89	22.86
Ash (%)	7.16	7.76	8.68	7.42

A: diet without the addition of rumen content; B: diet with 10% of rumen content; C: diet with 20% of rumen content; D: diet with 30% of rumen content. The premix contains the following per kilogram of diet: calcium 90 g/kg, phosphorus 10 g/kg, sodium 17 g/kg, cobalt 12 mg/kg, iron 250 mg/kg, copper 215 mg/kg, zinc 1100 mg/kg, manganese 900 mg/kg, iodine 15 mg/kg, selenium 1.50 mg/kg, Vitamin A 54,000 IU/kg, vitamin B 3,000 IU/kg.

Chemical and physicochemical analysis

Sample preparation and weighing

Prior to the analysis, feed ingredients were ground using an electronic grain mill (IKA A 11, Germany) designed for cereals, legumes, and forage crops with a moisture content ≤18%. Weighing of samples, reagents, and materials was performed using Shimadzu laboratory electronic scales (Japan) with high precision.

Nutrient composition analysis

Crude fiber, fat, protein, sugar, and starch contents were determined using the NIR DS 2500 feed analyzer (Sweden). The instrument performs near-infrared (IR) analysis of crushed, uncrushed, and granulated feed samples over a spectral range of 850–2500 nm that provides high analytical accuracy for nutrient determination.

Quality control procedures

To ensure the reliability of analytical results, all measurements were performed in triplicate. Instruments were calibrated according to the manufacturers' specifications prior to analysis. The MX-50 Moisture Analyzer (Japan) and Shimadzu electronic scales (Japan) were calibrated daily before usage. Ash content was measured in accordance with GOST 13979.6–69 using a SNOL muffle electric furnace (Lithuania). Samples were turned to ash at 650°C until a constant mass was achieved.The NIR DS 2500 (Sweden) analyzer was validated against certified reference samples to guarantee spectral accuracy across the full wavelength range. For ash determination, the muffle furnace temperature was cross-checked using a certified thermometer prior to experimental series. Macro- and microelement concentrations were determined in accordance with GOST 32343–2013. Vitamin content was determined using chromatographic methods specified in GOST 31483–2012. Organoleptic properties of the finished compound feed containing different levels of rumen content (color, odor, and structure) were assessed based on standard sensory evaluation practices.

Statistical analysis

Data were analyzed using one-way ANOVA with dietary treatment as the main factor. Individual animals served as experimental samples ($n = 5$). Differences among means were assessed using Tukey's HSD test, with significance level of $P < 0.05$. Statistical analyses were performed using OriginLab PRO.

RESULTS AND DISCUSSION

Physico-chemical parameters of cattle and sheep rumen content

The physico-chemical composition of the cattle and the sheep rumen content is presented in Table 3. No significant differences were observed in dry matter (DM) content between the cattle and the sheep rumen samples (92.10% vs. 92.19%, NS) that indicate a comparable overall solids content in both species. In contrast, crude protein (CP) content was significantly higher in the sheep rumen content than in the cattle (9.37% vs. 3.59%, $P < 0.05$). A similar trend was observed for the fat content, which was markedly greater in the sheep rumen content (2.21%) compared to the cattle (0.10%, $P < 0.01$).

Table 3 - Physico-chemical parameters of cattle and sheep rumen content

Variable	Cattle rumen content	Sheep rumen content	P-value
Dry matter (DM, %)	92.10	92.19	NS
Crude protein (CP, %)	3.59[b]	9.37[a]	<0.05
Fat (%)	0.10[b]	2.21[a]	<0.01
Crude fiber (CF, %)	36.93[b]	37.75[a]	<0.05
Nitrogen-free extract (NFE, %)	42.22[a]	33.67[b]	<0.05
Sugar (%)	0.67	-	-
Starch (%)	-	-	-
Ash (%)	9.26[a]	9.19[b]	<0.05
Calcium (Ca, %)	-	0.53	-
Phosphorus (P, %)	-	0.23	-
Amino acid composition			
Arginine	0.262[b]	0.347[a]	<0.05
Lysine	0.375[b]	0.596[a]	<0.05
Tyrosine	0.194[b]	0.244[a]	<0.05
Phenylalanine	0.300[b]	0.439[a]	<0.05
Histidine	0.094	0.087	NS
Leucine + isoleucine	0.387[b]	0.596[a]	<0.05
Methionine	0.081[b]	0.146[a]	<0.05
Valine + Proline	0.456[b]	0.596[a]	<0.05
Threonine	0.362[b]	0.509[a]	<0.05
Serine	0.350[b]	0.504[a]	<0.05
Alanine	0.293[b]	0.482[a]	<0.05
Glycine	0.368[b]	0.542[a]	<0.05
Vitamins			
A, mg/100g	-	-	-
E, mg/100g	22.13[b]	212.0[a]	<0.05
B1, mg/100g	0.024[a]	0.010[b]	<0.05
B2, mg/100g	0.030[a]	0.013[b]	<0.05
B3, mg/100g	0.094[a]	0.057[b]	<0.05
B5, mg/100g	0.051	0.044	NS
B6, mg/100g	0.017[a]	0.009[b]	<0.05
Mineral elements			
Ca, mg/100g	103.25	96.42	NS
P, mg/100g	118.61	115.63	NS
Fe, mg/100g	8.79[a]	5.06[b]	<0.05
Zn, mg/100g	3.16	3.22	NS
Mg, mg/100g	24.18[a]	21.5[b]	<0.05
Na, mg/100g	132.44[a]	109.74[b]	<0.05
K, mg/100g	208.96[b]	213.16[a]	<0.05
Cu, mg/100g	3.71[a]	1.95[b]	<0.05

Values within a row with different superscript letters (a, b) differ significantly at $P < 0.05$.. NS — not significant; "–" — not determined.

Crude fiber (CF), nitrogen-free extract (NFE), and ash content differed significantly between species (P < 0.05). Sugar and starch were not determined in either sample. The sheep rumen content was characterized by higher crude fiber levels, whereas the cattle rumen content contained a significantly higher proportion of nitrogen-free extract that suggests a greater amount of residual soluble carbohydrates. The analysis of the amino acid profile showed that most essential and non-essential amino acids (arginine, lysine, tyrosine, phenylalanine, leucine + isoleucine, methionine, valine + proline, threonine, serine, alanine, and glycine) were present in significantly higher concentrations in the sheep rumen content compared to the cattle (P < 0.05). Histidine content did not differ significantly between the two species (P > 0.05). For instance, lysine content was 0.596% in the sheep versus 0.375% in the cattle, while leucine + isoleucine accounted for 0.596% and 0.387%, respectively.

In case of vitamin composition, vitamin E and all analyzed B-group vitamins, except B5, were significantly higher in the sheep rumen content (P < 0.05). The evaluation of pantothenic acid (vitamin B5) showed that there is no significant difference between species. Among mineral elements, iron (Fe), magnesium (Mg), sodium (Na), potassium (K), and copper (Cu) differed significantly (P < 0.05), whereas calcium (Ca), phosphorus (P), and zinc (Zn) exhibited no significant variation.

Overall, the physico-chemical characteristics of the cattle and the sheep rumen content indicate their potential value as unconventional feed resources, which are consistent with earlier studies (Esonu et al., 2006; Agbabiaka et al., 2012;

Elfaki and Abdelatti, 2015; Mamudu et al., 2020). The higher crude protein and fat contents observed in the sheep rumen content are mainly attributed to the differences in feeding regimes, rumen microbial activity, and digesta retention time between small and large ruminants, as previously reported by Mamudu et al. (2020).

The high crude fiber content observed in both cattle and sheep rumen contents (36.93–37.75%) confirms that rumen digesta is a rich source of structural carbohydrates that supports earlier findings by Sakaba et al. (2017). Furthermore, the increased concentrations of important amino acids nutrition such as lysine, methionine, and threonine in the sheep rumen content suggest a higher contribution of microbial protein synthesized in the rumen, which has also been noted in previous reviews on rumen content utilization (Feedipedia, 2010).

The inclusion of rumen content

The inclusion of rumen content in the compound feed affected its organoleptic properties (Figure 1). The control diet (A, 0%) and the diet containing 10% of rumen content (B) showed a uniform color, homogeneous structure, and neutral odor. At 20% inclusion (C), a slight darkening of color and a minor increase in moisture were observed, while the feed remained organoleptically acceptable. However, the diet containing 30% of rumen content (D) exhibited a darker burgundy-brown color, reduced homogeneity with the appearance of small lumps, and a more pronounced odor.

Similar changes in odor and physical appearance of feeds containing rumen content have been reported in previous studies. Esonu et al. (2006) in their study on poultry, noted that dried rumen digesta imparts a characteristic odor to compound feeds, which may influence feed acceptance at higher inclusion levels. In addition, Okorie (2006) reported that increasing levels of rumen content in animal diets can affect sensory properties, particularly odor intensity that potentially reduces palatability. Furthermore, Yitbarek et al. (2020) found that moderate inclusion levels of rumen content can be used without adverse effects on feed quality, whereas excessive inclusion may negatively affect feed structure and acceptance. Organoleptic properties such as color, texture, and odor play a crucial role in determining feed palatability and voluntary intake in ruminants (Forbes, 2007).

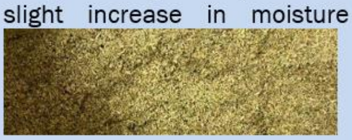
Feed		Color	Structure of the feed mixture	Odor
A		Uniform, light brown	Homogeneous, without lumps 	Neutral, without pronounced foreign impurities
B		Practically unchanged	Homogeneous, without lumps 	No significant changes
C		Slight lightening	Fairly homogeneous, with a slight increase in moisture 	Slightly more pronounced, but within acceptable limits
D		Light burgundy-brown	Less homogeneous, small lumps appear 	More pronounced, which may affect feed perception

Figure 1 - Comparative analysis of external characteristics of the feed mixture with different percentages of rumen content (Author's own illustration). A — diet without the addition of rumen content; B — diet with 10% rumen content; C — diet with 20% rumen content; D — diet with 30% rumen content.

Growth performance

Table 4 presents the growth performance of young Kazakh fine-wool sheep fed diets containing different levels of rumen content. Incorporation of rumen content into livestock diets allows recycling of valuable microbial protein and fermentation products; however, the high moisture content and unpleasant odor of such diets are recognized limitations. Rumen content contains microbial protein, volatile fatty acids, amino acids, and non-protein nitrogen, which can positively influence rumen fermentation and nutrient utilization.

Table 4 - Effect of different levels of rumen content in the diet on growth performance of Kazakh fine-wool sheep.

Variable	A	B	C	D	SEM	P-value
IBW (kg)	32.0	31.9	32.2	32.3	0.15	0.617
FBW (kg)	39.3[b]	39.6[b]	41.0[a]	39.0[b]	0.30	<0.001
TWG (kg)	7.3[b]	7.7[b]	8.8[a]	6.7[c]	0.20	<0.001
DWG (g/day)	122[b]	128[b]	147[a]	112[c]	4.1	<0.001
DFI (g)	680	690	670	650	20	0.094
FCR (F/G)	5.58[b]	5.37[b]	4.56[c]	5.80[a]	0.29	<0.001

A: diet without the addition of rumen content; B: diet with 10% rumen content; C: diet with 20% rumen content; D: diet with 30% rumen content. IBW: Initial body weight, FBW: Final body weight, TWG: Total weight gain, DWG: Daily weight gain, DFI: Daily feed intake, FCR: feed conversion ratio (kg of feed consumed per 1 kg of body weight gain). a-c: Means with different superscripts within a row differ ($P < 0.05$). SEM: Standard error of means.

In the present study, the inclusion of rumen content at 20% of the diet (Group C) resulted in the highest final body weight, total weight gain, and average daily gain, as well as the most favorable feed conversion ratio. In contrast, increasing the inclusion level to 30% (Group D) had a negative effect on growth performance.

Initial body weight did not differ significantly among treatments ($P = 0.617$) that indicates uniform starting conditions. Final body weight, total weight gain, and daily weight gain were significantly influenced by dietary treatment ($P < 0.001$). Sheep in Group C achieved the highest final body weight (41.0 kg), total gain (8.8 kg), and daily gain (147 g/day), whereas the lowest values were observed in Group D. These results suggest a nonlinear response of growth performance to increasing rumen content inclusion.

The superior performance of sheep fed in the 20% rumen content diet agrees with previous studies. Sadeghi et al. (2024) reported that inclusion of 20% biologically treated rumen content in calf diets significantly improved dry-matter and organic-matter digestibility, average daily gain, and feed efficiency. Similar positive responses to moderate rumen content inclusion (10–20%) are reported in lambs and cattle, suggesting that the microbial protein and fermentation products present in rumen content can support animal growth.

In contrast, the reduced performance observed in sheep fed of the 30% rumen content diet is consistent with earlier findings. Al-Wazeer (2016) reported that while 10–20% dried rumen content had no adverse effects on growth in Awassi lambs, a 30% inclusion level significantly reduced weight gain and feed efficiency. Similarly, higher inclusion levels were associated with reduced digestibility and increased fiber intake, which may limit nutrient availability. Collectively, the results indicate that rumen content inclusion above approximately 20% can impair growth performance in sheep.

CONCLUSIONS

In summary, findings of the study suggest that fine-wool sheep can consist up to ~20% slaughterhouse rumen content in the diet, the extent that is without negative effects and even gains slightly more weight to the sheep due to the extra microbial nutrients. However, inclusion above this level (30% in the present study) reduces feed intake and growth. The sensory issue (unfavorable sensory characteristics) and high fiber of rumen content likely caused the decline in Group D with 30% of rumen content. For future studies, it is recommended to optimize processing methods of rumen content to improve its palatability, as well as to evaluate its effects on other animal species.

DECLARATIONS

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Authors' contribution

Gulmira Kenenbay: development of the concept and design of the study, analysis of the obtained data, writing the original text of the manuscript. Urishbay Chomanov: statistical processing of data, literature review, editing of the text. Marzhan Idayatova: participation in the experiment, sample collection and laboratory analysis, correction of the manuscript. All authors approved the final version of the article and are responsible for the accuracy of the presented data.

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Data availability

The authors will provide the analysed datasets on reasonable request to the corresponding author.

Ethical regulation

All animal procedures were conducted in accordance with the Law of the Republic of Kazakhstan "On Responsible Treatment of Animals" (2021) and international guidelines for the welfare of farm animals. The experimental protocol was approved by the Ethics Committee of the Kazakh Research Institute of Processing and Food Industry LLP. The study was conducted and reported in accordance with the ARRIVE guidelines.

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Competing interests

The authors declare no competing interests.

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